Drilling and Test Pumping Report for One Borehole at Omauni Primary Health Care Clinic in the Ohangwena Region

Project Number: 2017-002

Report Number: 2017-D005

April 2017

Report

Prepared for Ministry of Health and Social Services

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Garnet Engineering CC

DOCUMENT INFORMATION

Title	Drilling and Test Pumping Report
Project Manager	S Nalusha
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Reviewer	
Client	Ministry of Health and Social Services & Garnet Engineering
Date last printed	
Date last saved	
Comments	
Keywords	Cuvelai basin, Omauni, Ohangwena Region, Kalahari sequence, Drilling, Test Pumping
Project Number	2017-002
Report Number	20117-D005
Issue Date	April 2017

DRILLING AND TEST PUMPING OF ONE BOREHOLE AT OMAUNI IN THE OHANGWENA REGION

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

Below a list of acronyms and abbreviations used in this report.

Acronyms / Abbreviations	**Definition**
GTC	Green Team Consultants
mm/a	Millimetre per annum
mm	millimetre
m_3/h	Cubic metres per hour
RWL	Rest Water Level
h	Hour
bgl	Below ground level
DPA	Discontinuous Perched Aquifer
MSAAN	Main Shallow Aquifer
MDAAN	Main Deep Aquifer
CDT	Constant Discharge Test
SDT	Step test Discharge Test
T	Transmissivity
TDS	Total Dissolved Solids
m	metre
Km	Kilometre
t(minute)	Time
AMSL	Above Mean Sea Level
ASL	Above Sea Level

DRILLING AND TEST PUMPING OF ONE BOREHOLE AT OMAUNI IN THE OHANGWENA REGION

1. INTRODUCTION

1.1 Background

Green Team Consultants CC (GTC) was appointed by Ministry of Health and Social Services through Twali Construction CC CC to drill and test pump one borehole at Omauni PHC clinic in the Ohangwena region. The borehole was drilled by Green Team Drilling Company with application of Mud Rotary drilling method.

1.2 Objectives

The report elaborates on the drilling and test pumping of borehole WW204779 drilled at Omauni clinic. The report further elaborates on the water analysis and installation recommendations.

1.3 General setting

The project location is in Ohangwena region. Ohangwena region is situated in the Cuvelai basin in the northern part of Namibia. The Cuvelai Basin is bordered in the south and west by the surface water divide running from Otavi to Outjo, Kamanjab, Otjovasandu, Otjondeka, Opuwo and Ruacana. In the east, the boundary is formed by a faint ground water divide running north from Tsintsabis almost at 18°E longitude, while in the north it is the international border between Angola and Namibia. The hydrogeological Cuvelai Basin thus comprises the Omusati, Oshana, Ohangwena, and Oshikoto regions and parts of the Kunene Region. Most of the land surface of the basin is very flat dipping from some 1150m above sea level (asl) in the north-east to 1 080m asl in the Etosha Pan,

which is the largest pan in Namibia. The Cuvelai Basin is the most densely populated area of Namibia and most of the inhabitants live in rural communities dependent on agriculture. Rainfall decreases from 600 mm/a in the north-east to 300 mm/a in the west. In the same direction, potential evaporation increases from 2 700 to 3000 mm/a. The project location is indicated in figure 1.

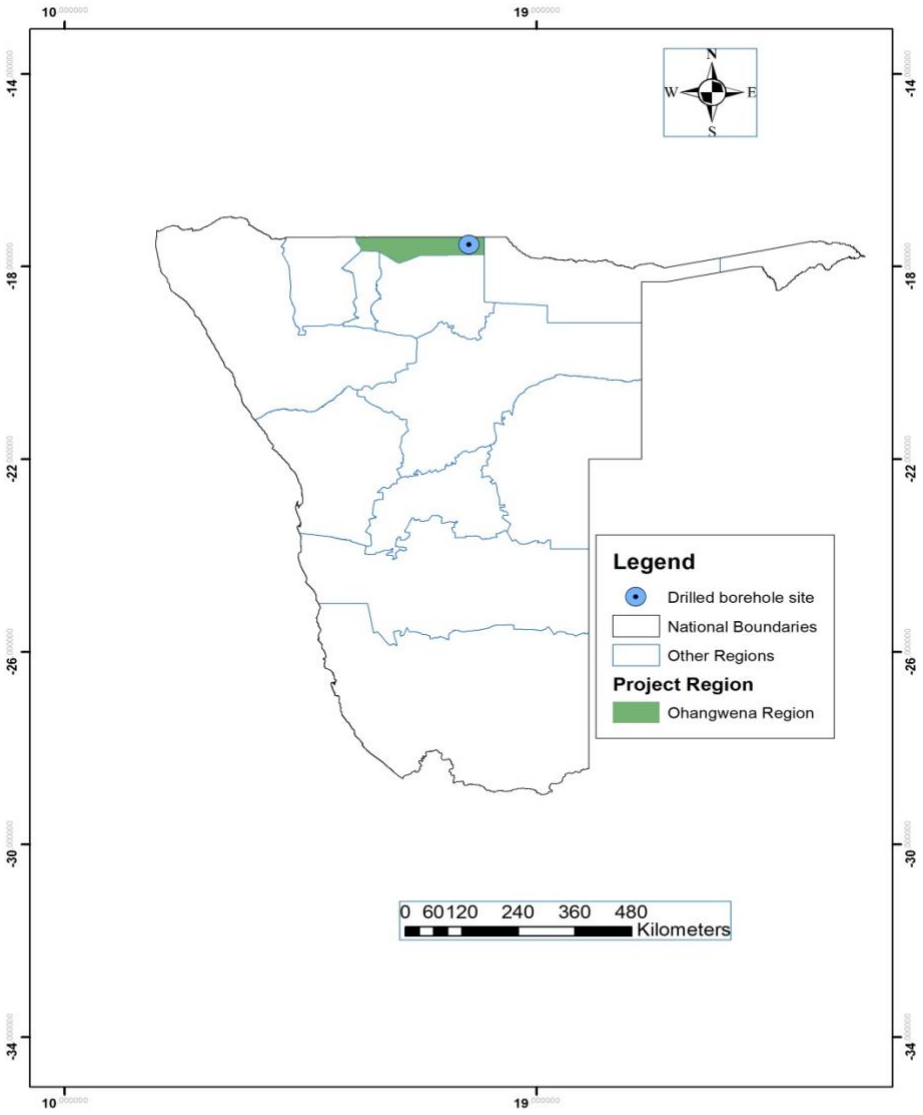

FIGURE 1: PROJECT LOCATION

1.4 Hydrogeological summary

All groundwater within the basin flows towards the Etosha Pan, due to the structure of the basin and because as the pan, as the deepest point, is the base level of the groundwater flow system. Groundwater, recharged in the fractured dolomites of the Otavi Mountain Land, flows northwards and feeds the aquifer system of the Karoo and Kalahari. The Kalahari Sequence comprises the Ombalantu, Beisib, Olukonda and Andoni formations. It is entirely of continental, aeolian to fluvial origin. The aeolian material consists of fine-grained, well-sorted sand, while the material deposited in a fluvial environment ranges from gravel to clay and often represents braided stream conditions, resulting in very variable lithologies both vertically and horizontally. Fluvial sedimentation dominates with some reworking of aeolian sand. The Kalahari Sequence Aquifers are split into an unconfined and a confined to artesian part. The Unconfined Kalahari Aquifers comprise two types of facies: the aquifer in the calcrete facies is classified as fractured, while the sand facies acts as a porous aquifer. The Unconfined Kalahari Aquifer is subdivided into the Discontinuous Perched Aquifer (DPA) above the Main Shallow Aquifer (MSAAN) in the north, the calcrete facies (UKAEL) in the south and west, and the sandy facies (UKAAN) in the centre around Oshivelo. The Discontinuous Perched Aquifer (DPA) is not a single aquifer, but consists of a series of small perched aquifers. The Main Deep Aquifer (MDAAN) is present in the eastern Ohangwena and northern Oshikoto regions. The groundwater flow is southward, towards the Etosha Pan, while the recharge area is probably located in southern Angola. Within the proposed project area, the porous aquifer is expected to be intersected at 60-160m bgl. Water quality in the area is generally good.

2. DRILLING AND TEST PUMPING RESULTS

2.1 Drilling results

The borehole was drilled with mud rotary drilling method with a final drilling diameter of 254 mm. targeting the main deep aquifer. Steel casing standpipe was installed to stabilise upper layers and prevent collapse of the borehole during drilling to a depth 6 m. uPVC casing with 165 mm outer diameter and a wall thickness of 9.5 mm was installed in all boreholes. Suitable gravel was emplaced in the annulus especially where perforated casing was installed to prevent sedimentation of fine particulates in the borehole. Drilling results are tabulated in **Error! Reference source not found.** below:

Location	WW Number	Latitude	Longitude	Results	Depth (m)	Rest Water Level
Omauni PHC Clinic	204779	-17.54363	17.71323	Intercepted saturated Kalahari aquifer	150	89.8

TABLE 1: DRILLING RESULTS

2.2 Test Pumping Results

An increasing Multi-rate Step Drawdown Test (SDT) was carried out at Omauni PHC clinic borehole, entailing a pumping and recovery phase. Based on the performance of the borehole during the SDT, a Constant Discharge Test (CDT) was carried out, where the borehole was pumped at a single rate for 8 hours followed by recovery. A discharge pipe was placed 100 m away from the borehole and a digital flow meter was used to measure the discharge rates. Sections below elaborate on the test pumping results.

2.2.1 Omauni PHC Clinic WW204779

A three step SDT was conducted, a summary of the results is given in Table 2. The CDT was conducted at a rate of 8 m³/h, Table 6 summarises the results.

Multi-Rate Test						
Pumping Phase (Pumping Start)				Recovery Phase (Pumping Stop)		
Time (h)	Pump rate (m3/h)	Water level (m bgl)	Cumulative Drawdown (m)	Time (h)	Water level (m bgl)	Recovery %
0	0	89.90	0.00	0	93.2	100
1	4	91.73	1.83	1	89.99	100
2	6	92.46	2.56	2	89.99	100
3	8	93.22	3.32	3	90.00	100

TABLE 2: STEP TEST RESULT SUMMARY

	Omauni PHC		PID = (m)	142	Depth = (m)	150
			RWL = (m)	89.9		
Step	Q	RWL	PWL	s	s'	s/Q
1	4.00	89.90	91.73	1.83		0.45750
2	6.00	89.90	92.46	2.56		0.42667
3	8.00	89.90	93.22	3.32		0.41500
Q_{main} =	**10 m^3/h**					
Step	Q	s/Q	Q/s	Aqu. loss	Well loss	%Eff.
1	4.00	0.458	2.186	12.132	1.518	88.8762
2	6.00	0.427	2.344	18.197	3.416	84.1934
3	8.00	0.415	2.410	24.263	6.074	79.9794

TABLE 3: STEP TEST ANALYSIS

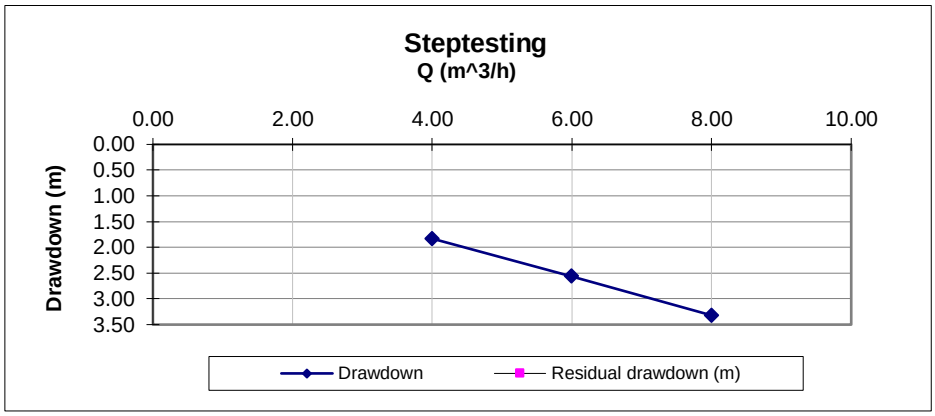

TABLE 4: STEP TEST DRAWDOWN GRAPH

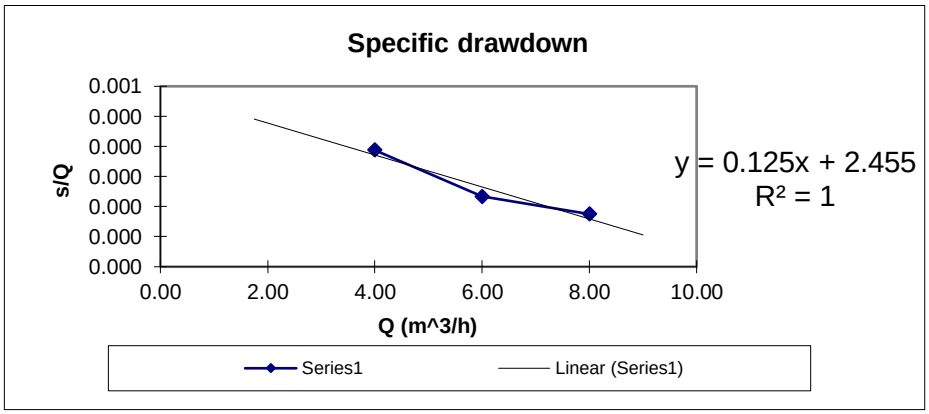

TABLE 5: SPECIFIC DRAWDOWN GRAPH ANALYSIS

Constant Discharge Test						
Pumping Phase (Pumping Start)				Recovery Phase (Pumping Stop)		
Time (h)	Pump rate (m_3/h)	Water level (m bgl)	Drawdown (m)	Time (h)	Water level (m bgl)	Recovery (%)
0	0.0	89.92	0	0	93.20	
8	8	93.20	3.28	8	89.83	100

TABLE 6: CONSTANT DISCHARGE TEST RESULT SUMMARY

2.3 Groundwater Quality Results

Water sample collected from the borehole was sent for analysis to Analytical laboratory in Windhoek. Classification of water quality from this borehole is believed to be in line with national guidelines based on the preliminary test result which was conducted on site.

Location	WW Number	Latitude	Longitude	Depth (m)	Water Analysis Results	Utilization
Omauni PHC Clinic	204977	-17.	17.	150	Results not available at time of submitting this report	To be utilized for human consumption

TABLE 7: GROUNDWATER QUALITY RESULT

Water Quality		
Parameter	Unit	Result
pH		8.24
EC (Conductivity)	mS/m	55.5
TDS (Total Dissolved Solids)	ppm	270
Salinity	ppm	0.27

TABLE 8: GROUNDWATER QUALITY TEST CONDUCTED IN THE FIELD

3. CONCLUSIONS AND RECOMMEDATIONS

3.1 Conclusion

GTC has been contracted by the Ministry of Health and Social Services through Twali Construction CC to drill and test pump one borehole at Omauni PHC clinic in the Ohangwena Region.

It is concluded that:

- Drilling and test pumping was successful.
- One borehole was drilled at the preferred location; drilling targeted the saturated aquifer.
- Test pumping evaluation indicates low drawdown with relatively good recovery; transmissivity shows that the borehole can be abstracted sustainably at a pumping rate than the constant discharge rate.

3.2 Installation Recommendations

Based on the test pumping evaluation the abstraction recommendations are given in table 9. Solar pump is recommended.

BH_ID	Recommended abstraction rate (m^3/h)	Maximum Pumping period (hours/day)	Recommended abstraction rate m^3/d	RWL (m bgl)	PWL1) (m bgl)	PID (m)
WW204977	3	7	21	89.9	142	130

1) Estimated from test pumping evaluation

TABLE 9: INSTALLATION AND ABSTRACTION RECOMMENDATION

4. REFERENCES

1. Christelis, G., & Struckmeier, W. (2001). *Groundwater in Namibia; an explanation to the Hydrogeological Map.* Windhoek: John Meinert Printing.
2. Mendelsohn, J., Jarvis, A., Roberts, C., & Robertson, T. (2009). *Atlas of Namibia.* Cape Town: Sunbird Publishers.

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Geologist

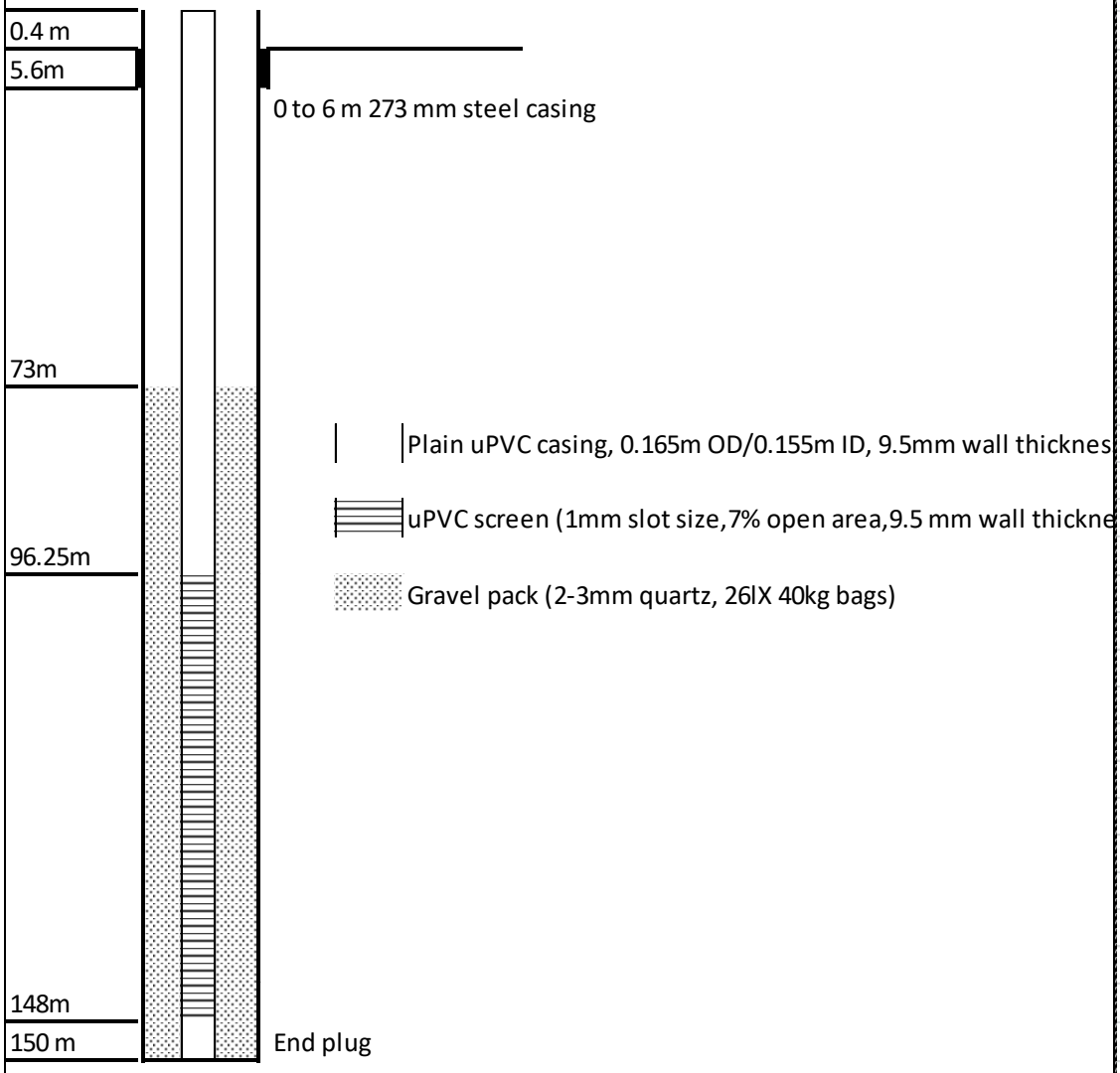
BOREHOLE DOMUMENTATION

APPENDIX 1: BOREHOLE COMPLETION REPORT

Drill Site Information			
Location:	Omauni PHC clinic	**Region:**	Ohangwena
WW No.	204779	**Site ID No.**	OM-01
Lat:	-17.54363	**Long:**	17.71323
Start Date:	16/04/2017	**End Date:**	19/04/2017
Drilling Results and Borehole Specifications			
Drilling Method:	Mud Rotary	**Drill Depth:**	150m
Drill Diameter:	0 to 6m = 311mm(12¼")	**UPVC Casings, 165mm:**	51.75m screen
	6 to 150m = 254 (10")		98.2.5m plain
Stand Pipe:	0 to 6m = 273(10")	**Water Strike:**	117m
Blow Yield:	8.6m³/h	**Water Quality:**	Fresh
Lithology:	0-5m: Red brown loamy Kalahari sand 5-15m: cream calcareous formation 15-23m: beige calcareous formation, sandy at places with haematite specks 23-73m: beige/white calcareous formation 73-81m: white sandy formation with calcrete nodules (minor aquifer?). 81-117m: greenish clay formation with calcrete nodules (possibly of Andoni formation?) 117-150m: grey/white sandy Kalahari formation with calcrete nodules at places(saturated Kalahari aquifer)		
Summary:	Very good yielding borehole,		

APPENDIX 2: BOREHOLE CONSTRUCTION AND CASING DESIGN

WW no	WW204779
Drill date	16/04/2017-19/04/2017
Lat	-17.54363
Long	17.71323
Datum	WGS84
RWL	89.92m
Drill diameter	0-6m: 0.311m; 6-150m: 0.254m



APPENDIX 3: NATIONAL GUIDELINES FOR EVALUATION OF DRINKING WATER

			WHO Guidelines for Drinking-Water Quality 1984	Council Directive of 15 July 1980 relating to the quality intended for human consumption 80/778/EEC		Namibia, Department of Water Affairs Guidelines for the evaluation of drinking-water for human consumption with regard to chemical, physical and bacteriological quality 20 October 1988			
Parameters and Expression of the results			**Guideline value (GL)**	**Guide level (GL)**	**Max. admissible concentration (MAC)**	**Group A Excellent Quality**	**Group B Good Quality**	**Group C Low Health Risk**	**Group D Unsuitable**
A. PHYSICO-CHEMICAL PARAMETERS									
Hydrogen ion concentration	**pH**	pH unit	6.5 to 8.5	6.5 to 8.5	9.5	6.0 to 9.0	5.5 to 9.5	4.0 to 11.0	4.0 to 11.0
Conductivity at 25 °C	**EC**	mS/m	-	45 at 20 °C: 40	-	150 -	300 -	400 -	400 -
Total dissolved solids	**TDS**	mg/l	1000	- Dry residues after drying at 180 °C	1500	-	-	-	-
Chlorides	**Cl**	mg/l	250	25	-	250	600	1300	1300
Sulphates	**SO_4**	mg/l	400	25	250	200	600	1200	1200
Total Hardness	$CaCO_3$	mg/l	500	-	-	300	650	1200	1200
Calcium	**Ca**	mg/l	-	100	-	150	200	400	400
	CaCO3	mg/l	-	250	-	375	500	1000	1000
Magnesium	**Mg**	mg/l	-	30	50	70	100	200	200
	$CaCO_3$	mg/l	-	7	12	290	420	840	840
Sodium	**Na**	mg/l	200	20	150	100	400	800	800
Potassium	**K**	mg/l	-	10	12	200	400	800	800
Aluminium	**Al**	µg/l	200	50	20	150	500	1000	1000
B. PARAMETERS CONCERNING SUBSTANCES UNDESIRABLE IN EXCESSIVE AMOUNTS									
Nitrates	**NO_3**	mg/l	45	25	50	45	90	180	180
	N	mg/l	10	5	11	10	20	40	40
Nitrites	**NO_2**	mg/l	-	-	0.1	-	-	-	-
Fluoride	**F**	mg/l	1.5	-	at 8 to 12 °C: 1.5	1.5	2.0	3.0	3.0
Boron	**B**	µg/l	-	1000	-	500	2000	4000	4000
Iron	**Fe**	µg/l	300	50	200	100	1000	2000	2000
Manganese	**Mn**	µg/l	100	20	50	50	1000	2000	2000
Copper	**Cu**	µg/l	1000	100	-	500	1000	2000	2000
Zinc	**Zn**	µg/l	5000	100	-	1000	5000	10000	10000
Barium	**Ba**	µg/l	-	100	-	500	1000	2000	2000
C. PARAMETERS CONCERNING TOXIC SUBSTANCES									
Arsenic	**As**	µg/l	50	-	50	100	300	600	600
Cadmium	**Cd**	µg/l	5	-	5	10	20	40	40
Chromium	**Cr**	µg/l	50	-	50	100	200	400	400
Nickel	**Ni**	µg/l	-	-	50	250	500	1000	1000
Lead	**Pb**	µg/l	50	-	50	50	100	200	200
Antimony	**Sb**	µg/l	-	-	10	50	100	200	200
Selenium	**Se**	µg/l	10	-	10	20	50	100	100
Vanadium	**V**	µg/l	-	-	-	250	500	1000	1000
D. FURTHER PARAMETERS									
Thallium	**Tl**	µg/l	-	-	-	5	10	20	20
Tin	**Sn**	µg/l	-	-	-	100	200	400	400
Uranium	**U**	µg/l	-	-	-	1000	4000	8000	8000